3D Interaction With and From Handheld Computers

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Figure 1: Interaction in front of a large screen with a PDA interface.

Abstract

3D user interfaces (3DUI) aim to enhance the user performance of 3D interactive tasks. In this paper we focus on the bridges between 3DUIs and handheld computers, following two directions. First, 3DUIs must be developed for efficient interaction with embedded 3D applications. Second, handheld computers can be useful for distant interaction with large displays in collaborative 3D applications.

We propose a new 3 DOF interface for interaction with 3D environments for these two directions. This interface is based on the analysis of the video stream coming from the embedded cameras for bimanual interaction with and from handheld computers.

1. Introduction

The use of handheld computers such as cell phones and PDA is becoming more widespread. The continued growth of computing resources allows for more and more complex 3D interactive applications on mobile settings. Following this evolution, screen resolution increases and the networks enhancement allows the design of actual client/server applications.

On the other hand, user interfaces for interaction with handhelds have barely evolved. Buttons allow the users to enter a few characters while direct pointers such as styluses associated to sensitive screens are well suited for 2D pointing in WIMP environments. However, interaction tasks related to new 3D applications are very different from the tasks required by simple schedulers and note editors. Consequently, new interfaces must be proposed in order to adapt the interface structure to the task structure.

In this paper, we describe a new interface developed for interaction with 3D environments displayed on handheld computers. Its success convinced us to extend our work to collaborative applications in which several handhelds are used as input devices for interaction with virtual environments (VE) displayed by collective visualization interfaces.

2. Interaction with handheld computers

Previous work

Input devices for handheld computers are not very common. The main works have been inspired by the pioneer investigations of Fitzmaurice et al. [1], where the device is moved in space. A more recent example is the Peephole display from Yee [2].

Other works are based on the analysis of the video stream coming from embedded cameras for augmented reality applications. For example, Wagner and Schmaltsieg [3] use ARtoolkit on a distant server to estimate the position of the handheld from markers that have been fixed in the real environment.

Our approach

We developed an interface where users control 3 DOF by moving a target with their dominant hand. The target is tracked from the embedded camera of the handheld computer held with the non-dominant hand. The 3 DOF relate to the xyz position of the target. Figure 2 illustrates this interface.

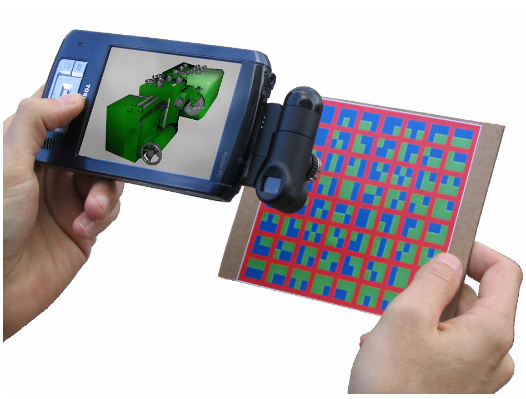

Figure 2: Bimanual camera-based interface.

We initially conceived our interface to enhance the visualization of displayed data. Indeed, one of the main limitations of handheld computers is the small visualization area provided by the screens. To avoid screen occlusion that occurs with pointing devices, we developed an interface that allows the screen to be permanently seen. Moreover, contrary to the described previous work, in our interface users do not have to move the handheld to interact with the data. Consequently, users can maintain the best possible view of the screen.

Implementation

We have developed a very fast algorithm that limits the CPU ticks on handheld computers. From the analysis of a few pixels, we can estimate the 3D location of the held target from the embedded camera. The target is made of a color code grid where each color code refers to a line and a column. This algorithm is described in detail in [4].

Interaction techniques

We have developed several interaction techniques in which our interface is used with handheld computers that allow users to perform such tasks as the visualization of large documents or interaction with 3D environments. For example, 3D objects can be manipulated by dividing the task into two subtasks. The objects' translations are directly mapped to the target's movements. When users want to modify the orientation of the objects, rotations are mapped to the movements of the target, as illustrated in figure 3.

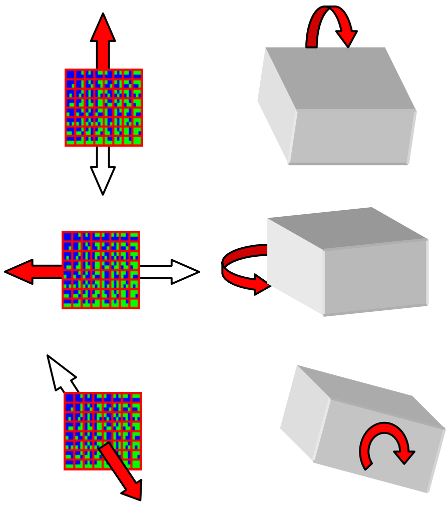

Figure 3: Object orientation.

Concerning camera viewpoint control for navigation in large 3D scenes, we developed a technique where left/right movements control the heading angle, up/down movements refer to the pitch angle, and forward/backward movements are used to go back and forth in the scene.

All the techniques used with our interface benefit from kinaesthetic feedback provided by bimanual interaction. Indeed, the actions are performed with the dominant hand according to the non-dominant hand, allowing users to easily interact with their data.

Generally, the numerous users who experimented with our interface have really enjoyed it. We conducted initial experiments that consisted of a targets-searching task. The results showed that our interface was faster than a classical stylus technique and that users also widely preferred it.

We extended this approach to collaborative contexts where several users visualize shared VE displayed on large screens. We are now going to describe this work.

3. Interaction from handheld computers

Collective visualization interfaces

Collective visualization interfaces allow several co-located users to simultaneously visualize the same VE. Consequently, such systems are very powerful for collaborative applications. An example is IllusionHole [5] where several users can visualize 3D models with correct personal viewpoints.

Despite the potential of collective visualization interfaces, at present actual collaborative applications limited because users generally cannot easily and efficiently interact with the VE.

Previous work

Some devices have specifically been developed to favor collective applications. For example, the CAT [6] is a 6 DOF freestanding device that can easily be shared by several participants for general interaction tasks.

Other devices can nicely be used as personal interfaces for interaction with the VE, such as laser pointers and handheld computers. On the one hand, laser pointers associated with cameras and computer vision algorithms are very light. They allow easily pointing parts of the screen. However, they are limited to monoscopic applications. On the other hand, handheld computers embed CPU and allow wireless connections. Consequently, they are very interesting as collaborative devices.

Watsen [7] primarily used a PDA as a remote control for interaction with VE. Hartling et al. [8] extended this approach by developing Tweek, a dedicated toolkit that can be integrated within VRJuggler applications.

However, current handheld computer interfaces are limited to 2D interaction techniques. Actually, users can only perform actions by stylus or the buttons of the handhelds. This lack of DOF limits interaction with 3D environments.

A new interface for interaction with VE

We have developed some test applications where the camera-based interface described above is used as a distant input device for interaction with the shared VE.

Similar interaction techniques can be used, the 3D data being displayed on the large screens rather than being displayed on the small handheld screens.

For example, from anywhere in front of the large screen, users can move their dominant hand from the embedded camera to navigate inside the VE (figure 1). Hence, users benefit from bimanual interaction in actual mobile settings. Figure 4 illustrates the use of our interface with the IllusionHole.

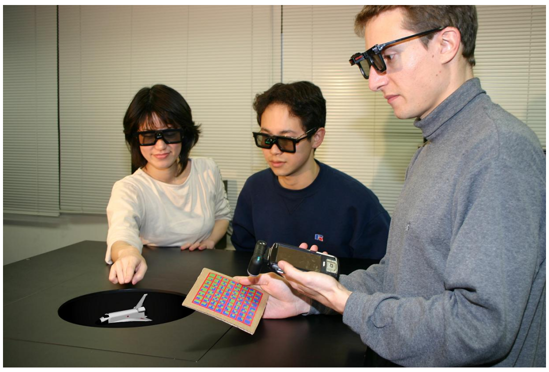

Figure 4: Interaction with the IllusionHole.

Implementation

A WIFI client/server configuration was used. The server at which the application is running listens for the client's handheld connections. Once the connection is established, the server asks for the client's inputs for each frame.

The handhelds permanently estimate the x, y, and z positions of the target from the embedded cameras.

These coordinates as well as the state of the current buttons are sent to the server when requested.

At the moment, we have developed some test applications where users interact one after the other. From this starting point, real collaborative applications can be developed.

A universal interface

We described a configuration where one server is used. The same approach has great potential when several servers associated to several visualization interfaces are available.

For example, we can imagine a user who interacts with 3D data displayed on her personal handheld computer. When working with colleagues in front of a huge screen in a collaborative session, the user connects to the server to interact with the shared data by using the same interaction techniques. She does not have to use any other input device or learn any new techniques. Hence, the same techniques will be used for each of the available visualization interfaces.

4. Conclusion

Handheld computers are becoming a more widespread part of our everyday lives. Their endless capacity will lead to more and more future complex applications. This evolution has to be followed by the evolution of user interfaces. In particular, adapted 3D user interfaces have to be developed for new 3D applications.

Moreover, immersive visualization interfaces can benefit from handheld computers for interaction, particularly when collaborative works are required. Indeed, each participant can join a given collaborative application by interacting from his/her personal device.

In this paper, we have presented a new 3DUI for interaction with and from handheld computers. The next step consists of integrating this new interface to actual complex 3D collaborative applications.

5. References

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